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Status and Trends of Predator Species in Lookout Point Reservoir

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Summary

Predation has been identified as a possible limiting factor to Chinook salmon in Lookout Point (LOP) Reservoir. To aid juvenile salmonid downstream passage through LOP Reservoir and dam, the USACE is examining several reservoir drawdown scenarios. The main objective of this study is to provide baseline (pre-drawdown) data on relative abundance, size, and distribution of predators (northern pikeminnow, walleye, largemouth bass, and crappie) in LOP Reservoir to help assess the effect of a possible LOP drawdown or similar operations. Results of this work are provided in the first section of this report. In the second section, we provide results from a radio-telemetry study on the movement and distribution of northern pikeminnow tagged in the reservoir.

During May and June of 2013-2015, we conducted boat electrofishing, gill netting, and Oneida Lake trap netting to capture predatory fish in LOP Reservoir using a standardized sampling design. We randomly selected reaches for sampling in 2013, but in 2014 and 2015 we established fixed reaches and more than doubled our sampling effort for electrofishing and gill netting. Catch per unit effort (CPUE) for each gear type was used to evaluate differences in abundance of predators among years and fork lengths (FL) were analyzed to evaluate the size of predators and changes in year-class strengths among years.

We collected 275 predatory fish in 2013, 652 in 2014, and 699 in 2015. Northern pikeminnow were the most common predator species collected in 2013 and 2014. In 2015 northern pikeminnow, crappie and bass were caught in similar numbers. Catch per unit effort varied among years for some species. Northern pikeminnow CPUE via electrofishing was significantly greater in 2013 compared to 2014-2015, whereas CPUE in sinking gill nets was significantly greater in 2014-2015 than in 2013. The higher CPUE in 2013 was the result of large catches of fish in the 200-280 mm FL size range that we did not observe in subsequent years. Most northern pikeminnow in 2013 may have been too small to be efficiently captured in gill nets but additional growth by 2014 potentially increased their vulnerability to gill netting. Largemouth bass CPUE was significantly greater in 2015 than other years, mainly the result of increased recruitment of smaller fish (<180 mm FL). Annual increases in the size of northern pikeminnow, crappie, and walleye were evident, indicative of somatic growth of fish within individual cohorts. Differences in species-specific CPUE among years appears to be the result of gear size-selectivity and changes in the size structure of the population as individual cohorts grew and became recruited to or excluded from a specific gear type.

Length frequency distributions suggested some predator species were dominated by strong year-classes. Crappie in LOP appeared to be dominated by a strong year-class from the 2010 brood year with little recruitment to the population since that time. Older age classes of walleye appeared to be declining, while a relatively younger year class (2012 brood year) was evident in our catch. Largemouth bass length frequencies exhibited a broad size range suggesting the presence of several year classes. Growth of fish within a year-class was evident between years for most species and the growth may have resulted in changes to vulnerability to gear types between years. The variability in year-class strength may mask the effect of a reservoir operation on predator recruitment and possibly bias results of a drawdown if strong year-class recruitment is not considered. Additional years of sampling may help clarify some of the

predator population dynamics in LOP Reservoir, and a pre-drawdown assessment should be conducted immediately prior to a reservoir drawdown to reduce confounding effects from strong year-classes.

Twelve adult northern pikeminnow (374-463 mm FL) were radio-tagged in the reservoir in May 2015; 10 survived and were tracked over 18 separate occasions through September 2015. Generally, fish movement patterns could be categorized as either localized within the reservoir or reservoir-to-river movement possibly associated with spawning. Fish that remained in the reservoir (n=6) generally stayed in the reservoir zone where they were tagged. The average distance travelled between tracking occasions ranged from 0.5 -1.8 km. The four fish that migrated upstream into the Middle Fork Willamette River were ≥410 mm FL. Three of these were tracked to the lower North Fork Middle Fork Willamette River in mid and late June; two were observed in a large trench pool with >100 large northern pikeminnow in what we infer was a spawning aggregation.

We recommend further investigations into the spawning habitat and timing of predator species in LOP, including fry abundance, to aid in our understanding of predator population dynamics. Understanding the spawning requirements and timing of each predator species could be useful in managing their populations since many of the predators species in LOP Reservoir spawn in shallow habitats in the spring. Manipulating reservoir elevations during the peak spawning time of these species could reduce recruitment to the populations, and eventually, predation on juvenile salmon.

Introduction

In 1999, the Upper Willamette River (UWR) spring Chinook salmon (*Oncorhynchus tshawytscha*) Evolutionarily Significant Unit (ESU) was listed as threatened under the U.S. Endangered Species Act (NMFS 1999), and this status was reaffirmed in 2005 (NMFS 2005). Historically among the most productive populations of the ESU, the Middle Fork Willamette River (MFW) population of spring Chinook salmon has suffered a precipitous decline during the past century, primarily caused by impacts from Willamette Valley Project (WVP) dams that block adult migrations to historical spawning grounds and limit successful outmigration of juvenile Chinook salmon produced above the Projects (Hutchison et al. 1966; NMFS 2008; Keefer et al. 2010). The National Marine Fisheries Service (NMFS) concluded in the 2008 Willamette Project Biological Opinion (BiOp) that the continued operation and maintenance of the WVP would jeopardize the continued existence of UWR Chinook salmon and winter steelhead (*O. mykiss*) and that the lack of fish passage through dams and reservoirs has one of the most significant adverse effects on both species and their habitat (NMFS 2008). Recognizing these potential threats, NMFS (2008) recommended that Action Agencies assess juvenile fish passage through WVP reservoirs (RPA 4.10) and dams (RPA 4.11) as an initial step toward assessing and improving juvenile downstream passage. In particular, RPA 4.10 discusses the need for site-specific research aimed at salmonid reservoir use and possible predation issues within reservoirs that may be causing substantial levels of juvenile salmonid mortality.

The WVP consists of 13 dams and reservoirs managed jointly by the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation. All 13 WVP dams are operated to capture and store water from mid-November through January to minimize the risk of downstream flooding, and together they control 27% of the total Willamette River drainage (NMFS 2008). In the MFW subbasin four WVP dams currently block adult upstream migration and lack juvenile downstream migration facilities. The MFW watershed encompasses 3,509 km^2 and joins the mainstem Willamette River at river kilometer (rkm) 299. Transport and release of adult Chinook salmon into historical MFW spawning grounds above Dexter and Lookout Point reservoirs began in 1993 (NMFS 2008). Although these actions were originally intended to provide forage for native bull trout (*Salvelinus confluentus*) the ancillary benefit of augmenting natural production of Chinook salmon in the subbasin soon became a priority (NMFS 2008). Successful spawning above Lookout Point (LOP) Reservoir was particularly encouraging in light of high pre-spawn mortality and low egg survivorship observed below Dexter Dam (McLaughlin et al. 2008; NMFS 2008). However, major challenges accompanied this approach towards recovery with direct downstream passage through LOP and Dexter dams and reservoirs thought to cause unacceptably high levels of juvenile mortality (NMFS 2008). Besides direct mortality from dam passage, predation by piscivorous fishes in these reservoirs may be taking a large toll on outmigrating juvenile Chinook salmon in the MFW (Brandt et al. *in review*, Monzyk et al. 2013), and predation has been identified as a limiting factor or threat affecting the abundance, productivity, and spatial structure of Chinook salmon in the upper Willamette basin (ODFW and NMFS 2011).

Most juvenile Chinook salmon enter LOP Reservoir in the spring (February-June) as fry (<60 mm FL), and exit LOP Reservoir in the fall and winter (November-December) as subyearlings (200-275 mm FL) with a few yearlings (>300 mm FL) that were presumably delayed by dam/reservoir passage (Romer et al. 2012, 2013; Keefer et al. 2012). Juvenile Chinook salmon abundance in LOP remains high throughout the spring in the upper portion of the reservoir near the MFW entrance with fish utilizing habitat in the shallow littoral area. As the salmon grow and temperatures rise (July-September), they move off-shore into deeper waters then move back towards the surface when temperatures start to decrease in the fall (Monzyk et al. 2012, 2013). The pattern of offshore movement by juvenile Chinook salmon has been shown in numerous other studies in lentic (Tabor et al. 2007) and lotic (Ingram and Korn 1969; Lister and Genoe 1970; Dauble et al. 1989; Friesen et al. 2007) environments. Dam- and reservoir-related outmigration delays, habitat overlap with warm-water piscivorous species, and their small size at reservoir entry make juvenile Chinook salmon in LOP Reservoir especially susceptible to predation (Romer et al. 2012, 2013; Monzyk et al. 2012; Brandt et al. *in review*).

Concerns have been raised about the impacts that piscivorous predators in WVP reservoirs have on outmigrating juvenile Chinook salmon, particularly in LOP Reservoir (ODFW and NMFS 2011). Monzyk et al. 2012 concluded that juvenile salmonids in LOP Reservoir were at greater risk of predation than any of the other WVP reservoirs they studied based on the species composition and relative abundance of predators in that reservoir. Brandt et al. (*in review*) conducted a paired release study in which hatchery-origin juvenile Chinook salmon were released above and below LOP dam and found that fish released above the dam were significantly less likely to be detected at Willamette Falls than those released below the dam and they postulated that predation in LOP Reservoir was a factor in this difference. A diverse assemblage of piscivorous fish species reside in LOP Reservoir including crappie (*Pomoxis spp.*), walleye (*Sander vitreus*), northern pikeminnow (*Ptychocheilus oregonensis*), largemouth bass (*Micropterus salmoides*), rainbow trout (*O. mykiss*), and cutthroat trout (*O. clarkii*) (Monzyk et al. 2011, 2012). The vast majority of crappie in LOP are white crappie (*P. annularis*) but black crappie (*P. nigromaculatus*) are also present. Crappie, walleye, northern pikeminnow and bass are known to prey on Chinook salmon in LOP and other reservoirs (Monzyk et al. 2013; Brown and Moyle 1981; Beamesderfer and Rieman 1991; Poe et al. 1991; Tabor et al. 1993; Zimmerman 1999). In LOP Reservoir, northern pikeminnow, largemouth bass, and walleye were found to have the greatest percentage of fish in their diets, but given that northern pikeminnow are the most abundant piscivorous predator in LOP Reservoir, they likely represent the greatest predatory threat even though walleye had the greatest overall consumption rate of juvenile Chinook salmon (Monzyk et al. 2011, 2012). Though northern pikeminnow are a native species and natural predators of juvenile salmonids, the development of the WVP in the MFW has likely increased northern pikeminnow numbers and predation beyond historical and natural levels (NMFS 2008; Monzyk et al. 2013). Monzyk et al. (2013) estimated the number of large (≥150 mm FL) northern pikeminnow in the littoral zone of LOP Reservoir to be about 7,100 individuals which consume an estimated 102,000 juvenile Chinook salmon every year from April-June (0.160 fish/day). In addition, a large population of northern pikeminnow resides in Dexter Reservoir directly downstream of LOP Dam, as evidenced by an annual pikeminnow derby where anglers remove thousands of pikeminnow in a single weekend each year. Various studies in the Columbia River basin have also found northern pikeminnow to be important predators of juvenile salmonids in reservoirs and tailraces (Beamesderfer et al. 1996; Vigg et al. 1991; Zimmerman 1999), though a few studies have found salmonids to be a small part of the diets of northern pikeminnow and other predators such as largemouth bass and walleye in lotic systems (Friesen 2005; Summers and Daily 2001; Buchanan et al. 1981; Brown and Moyle 1981). Beamesderfer et al. (1996) estimated the average daily consumption rate of northern pikeminnow in the Columbia and Snake rivers to be 0.06 salmonids/predator, and Vigg et al.

(1991) found northern pikeminnow to be the major predator of juvenile salmonids in John Day reservoir with an average daily consumption rate of 0.7 salmonids/predator. In lakes, northern pikeminnow have been observed to remain near shore for much of the year (Beauchamp 1994; Olney 1975) which overlaps with juvenile Chinook salmon littoral habitat use in the spring, likely leading to substantial rates of predation.

Multiple non-native piscivorous species in LOP Reservoir also pose serious threats to outmigrating juvenile Chinook salmon. Centrarchid abundance in LOP Reservoir is high, particularly for largemouth bass and crappie (Monzyk et al. 2012). Studies by Reimers (1989) and Fritts and Pearsons (2004) found declines in salmonid populations from black bass predation in Oregon and Washington, and bass are especially dangerous to juvenile salmonids when there is habitat overlap in littoral areas (Gray and Rondorf 1986; Tabor et al. 2007), a condition that exists during the spring in LOP Reservoir (Monzyk et al. 2012). Diet samples collected from crappie in Hills Creek and LOP reservoirs anecdotally suggested high levels of predation on PIT-tagged fish released for a paired release study in 2012 (Brandt et al. *in review*). Predation of juvenile Chinook salmon by walleye has been documented in LOP Reservoir (Monzyk et al. 2011, 2012) and the Willamette River (Tinus and Beamesderfer 1994) with heavy predation in littoral areas and tributaries after juvenile Chinook salmon emergence. Vigg et al. (1991) estimated the daily consumption rate of juvenile salmonids by walleye in John Day Reservoir to be 0.2 salmonids/predator.

Currently, the lack of fish passage facilities at LOP Dam to aid in the downstream passage of juvenile Chinook salmon represents a potentially serious threat to Chinook salmon populations in the MFW subbasin (NMFS 2008). Juvenile salmon that successfully navigate through LOP Reservoir must pass through hydroelectric turbines or regulating outlets that can pose another source of mortality (Čada 2001; Muir et al. 2001; Ferguson et al. 2006; Keefer et al. 2013). To aid juvenile salmonid downstream passage through LOP reservoir and dam, the USACE is examining several reservoir drawdown scenarios that would be more conducive to juvenile outmigration (Peters et al. 2001; Tiffan et al. 2006; USACE 2012). With a well-timed drawdown the amount of time juvenile salmon are exposed to predators, littoral habitat overlap, predator access to littoral spawning areas, and predator recruitment should be reduced, which, in conjunction with improved downstream passage, should significantly enhance juvenile Chinook salmon outmigration success (Mense 1982; Rogers and Bergersen 1995; USACE 2012; Keefer et al. 2012; USACE 2014). In addition, a drawdown could result in dewatering of eggs from predators spawning in shallow reservoir habitat. The USACE has already implemented drawdown in the MFW subbasin on Fall Creek reservoir with promising results (Miller and Friesen 2012; USACE 2014). Fall Creek reservoir has been drawn down to run-of-the river levels every year since 2011 to aid juvenile Chinook salmon downstream passage and remove piscivorous predators, and preliminary results suggested that Chinook salmon outmigration was improved and predator numbers were substantially reduced (Greg Taylor USACE-pers. comm.). However, there are potential issues that may arise from a reservoir drawdown that should be examined, such as a possible increase in predation from the concentration of predators and prey into a small residual pool (Heman et al. 1969; Miller and Friesen 2012).

The impact of a reservoir drawdown on predator populations would depend on the timing and magnitude of the drawdown and the specific life-history characteristics of the predator species. Miller and Friesen (2012) provided a detailed review of species-specific life histories for predators that are found in LOP Reservoir. It is apparent from the life-history diversity of LOP predators that information on abundance, habitat use, spawning and rearing distribution is needed to evaluate drawdown success in reducing predation risks to juvenile Chinook salmon. Sammons and Bettoli (2000) and Mitzner (1991) found that survival and recruitment of young black bass and crappie were positively related to reservoir water storage with the critical storage period for bass in the late summer (larval survival) and spring for crappie (spawning). Beam (1983) also observed a negative correlation between flood water releases and crappie year class strength. Though walleye may spawn in tributaries in the spring, high discharge/flush rates and increased water level may be detrimental to walleye survival and recruitment (Tinus and Beamesderfer 1994; McMahon and Bennett 1996; Venditti 1994). Northern pikeminnow are known to spawn in rivers and shallow littoral zones of reservoirs (Jeppson and Platts 1959), but their spawning behavior and habitat use in the MFW are currently unknown. In addition to varying responses to discharge, pool height, and drawdown timing, predation levels are often site-specific and can depend on a number of different variables such as prey abundance, water temperature, predator/prey size, and spatial/temporal overlap of habitat (Miller and Friesen 2012; Vigg et al. 1991; Ward et al. 1995). Thus, it is necessary to determine a baseline, site specific understanding of these relationships prior to any treatment to control piscivorous predators through manipulation of flow management (flushing flows, drawdown of reservoir pool elevation at key times).

SECTION 1: BASELINE MONITORING OF PREDATOR POPULATIONS IN LOOKOUT POINT RESERVOIR

Background

To address the need for baseline data regarding possible sources of mortality for juvenile Chinook salmon migrating downstream through reservoirs and dams in the Willamette basin (RPAs 4.10 and 4.11; NMFS BiOp) we initiated systematic, standardized sampling in LOP Reservoir in 2013 and continued this effort in 2014 and 2015. The objectives of this study were to provide information on relative abundance, size, and distribution of predator species of concern (northern pikeminnow, walleye, largemouth bass, and crappie) to help assess the effect of possible LOP drawdown or similar operations on piscivorous predators. Because predator abundance is site specific and can vary both spatially and temporally, we used a repeatable, standardized approach which provides consistent and measurable predator community metrics that will be useful for detecting changes in predator abundance and community structure post-drawdown. This information will also provide a better understanding of the survival benefits and risks for juvenile Chinook salmon rearing in reservoirs and can be used to guide further management decisions regarding downstream passage of juvenile Chinook in LOP Reservoir. In this report, we provide information on species-specific relative abundance and size of predators in LOP Reservoir from data collected in 2013-2015.

Methods

All sampling took place May-June, 2013-2015 in LOP Reservoir, a 22.8 km long impoundment that covers an area of 1,764.5 ha at full pool (www.nwp.usace.army.mil/). Submerged vegetation and stumps are the primary form of structure in the reservoir, and reservoir depth increases gradually moving from the head of reservoir to the dam (mean depth=32 m; www.nwp.usace.army.mil/).

Methods used for standardized sampling of predatory fish in 2013 included boat electrofishing, Oneida Lake traps, sinking gill nets, and floating gill nets. Different gear types were used to minimize potential bias associated with size selectivity and behavioral differences among predator species. Standardized electrofishing and gill netting were limited in 2013 because effort was also directed towards conducting a northern pikeminnow abundance estimate (Monzyk et al. 2013). In 2014-2015, sampling effort using these methods was increased. Sampling was conducted in May and June of all years, after the reservoir reached its fullest pool elevation.

The reservoir was divided into three zones (Upper, Middle, Lower) of approximately equal sizes and varying depths for stratified sampling purposes. Moving from the Upper zone at the head of the reservoir to the Lower zone at the dam, reservoir depth increases and habitat type and availability varies. In 2013, the entire shoreline was broken into roughly equal sized (400 m) reaches within each zone, and each reach had an equal probability of being chosen for a given netting or electrofishing sampling event (Figure 1). Reach selection for sampling was changed slightly in 2014-2015. Eight fixed reaches per zone that were approximately equal in size (400 m) were chosen for boat electrofishing and the remainder of shoreline was divided into nine reaches in the Upper and Lower zones and eight reaches in the Middle zone of approximately equal size specific for Oneida and gill net sampling (Figure 2). The lower pool elevation in 2015 resulted in the dewatering of the five uppermost reaches (U3-U7). Only reaches U1, U2, and U8 were sampled along with a new 400-m reach at the head of reservoir. Fixed electrofishing sites were subjectively chosen to avoid steep cliff faces that rarely held fish and were spaced relatively evenly apart throughout the reservoir.

In 2013 we conducted boat electrofishing (Smith Root model 2.5 generator powered pulsator) over two weeks (three nights per week) with equal effort per zone within weeks. In 2014-2015 sampling took place over four weeks (three nights per week), with equal effort per zone within weeks. In 2013, a zone was chosen and six reaches within that zone were randomly selected for a given night, and in 2014-2015 all eight electrofishing reaches within a chosen zone were sampled per night. Besides sample site selection and reach determination, electrofishing protocols were standardized for comparability across years. Only nighttime shocking was conducted, and each unit of electrofishing effort consisted of 15 minutes (900 s) of continuous shocking time. The electrofisher settings were kept at approximately 850 V with a pulse width of 5 ms, and a frequency of 120 DC for the entirety of sampling. The starting reach was chosen randomly at the start of every sampling event, and all shoreline areas (i.e. shallow and deep areas) within a reach were shocked. All predator species encountered were collected, and at the end of each 15-minute session the number of each fish species captured was recorded and each fish was measured (FL to nearest mm). In addition, we recorded water temperature and GPS coordinates at the beginning and end of each reach sampled.

Along with electrofishing, standardized gill net and Oneida trap deployment was conducted in LOP Reservoir in May and June. In all years, floating and sinking gill nets were deployed in pairs at three randomly chosen reaches (one per zone) each night. In 2013, gill nets were fished three nights in the final week of May and four nights in the final week of June, with roughly equal effort across zones. In 2014-2015, gill nets were fished four nights per week (except Memorial Day week), two weeks per month, with roughly equal effort across zones. In all years, gill nets were experimental type nets that consisted of four 7.6 m x 3.0 m panels of different mesh size (3.8-cm, 5.1-cm, 6.4-cm, 7.6-cm square mesh). The unit of sampling effort was an individual gill net fished at a reach for approximately 24 hours. All gill nets were deployed perpendicular to shore with the smallest mesh closest to the bank. Fish captured in the floating and sinking nets were recorded separately, and for each net the number of each species captured was recorded and each fish was measured.

Oneida Lake trap sampling protocol differed slightly from gill net sampling protocol for all years. In 2013, one Oneida trap was deployed in a randomly chosen reach each night. Oneidas were fished three nights in the first and final week of May and four nights in the final week of June, with roughly equal effort across zones. For 2014-2015, one Oneida trap was deployed at a randomly chosen reach each night. Oneidas were fished three nights per week (one per zone), two weeks per month, with roughly equal effort across zones. Oneida traps consisted of a 0.64 cm mesh holding box (2.4 m x 2.4 m x 2.4 m) with a lead net (34.1 m x 3.0 m) extending from shore to the box and two wings (7.2 m x 3.0 m) set at 45° angles leading into the box. Oneida traps were designed to intercept fish moving within 34.1 m along the shoreline and in the upper 3.0 m of the water column. The unit of sampling effort consisted of an individual Oneida trap fished at a reach for approximately 24 hours. All Oneidas were deployed perpendicular to the shore, and fish captured were identified to species, counted, and measured (FL to nearest mm).

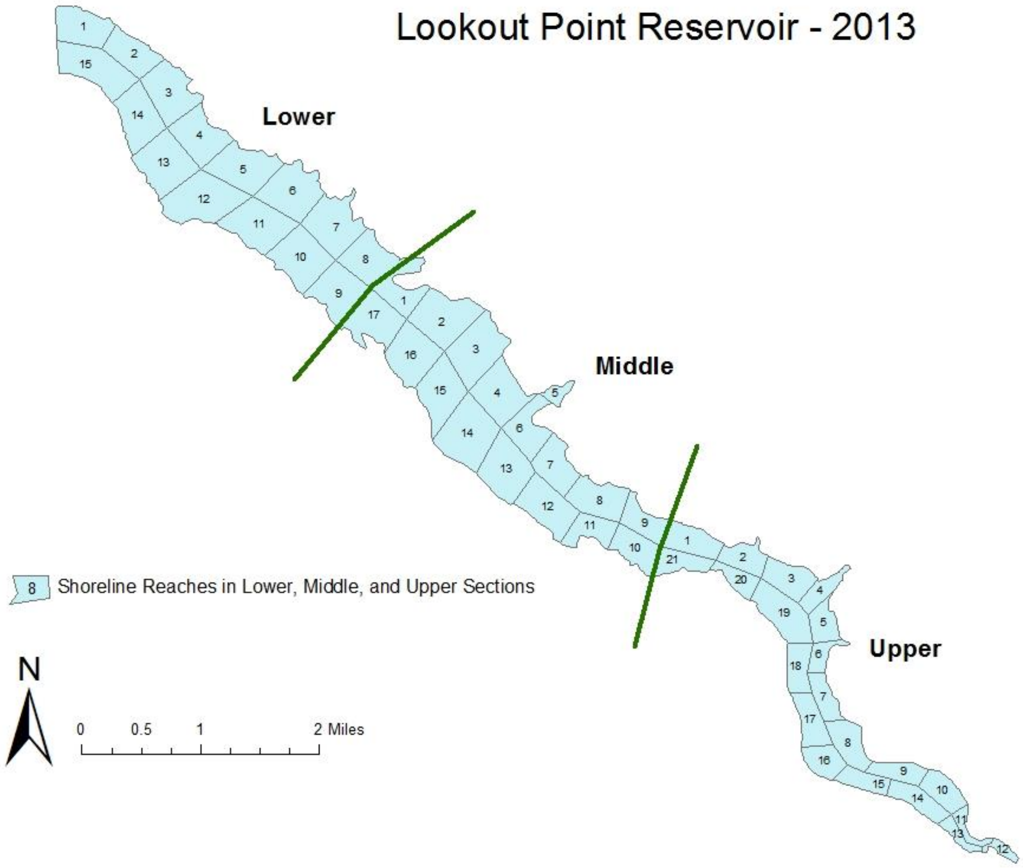

Figure 1-1. Zone and reach breaks used for sampling in Lookout Point Reservoir in 2013

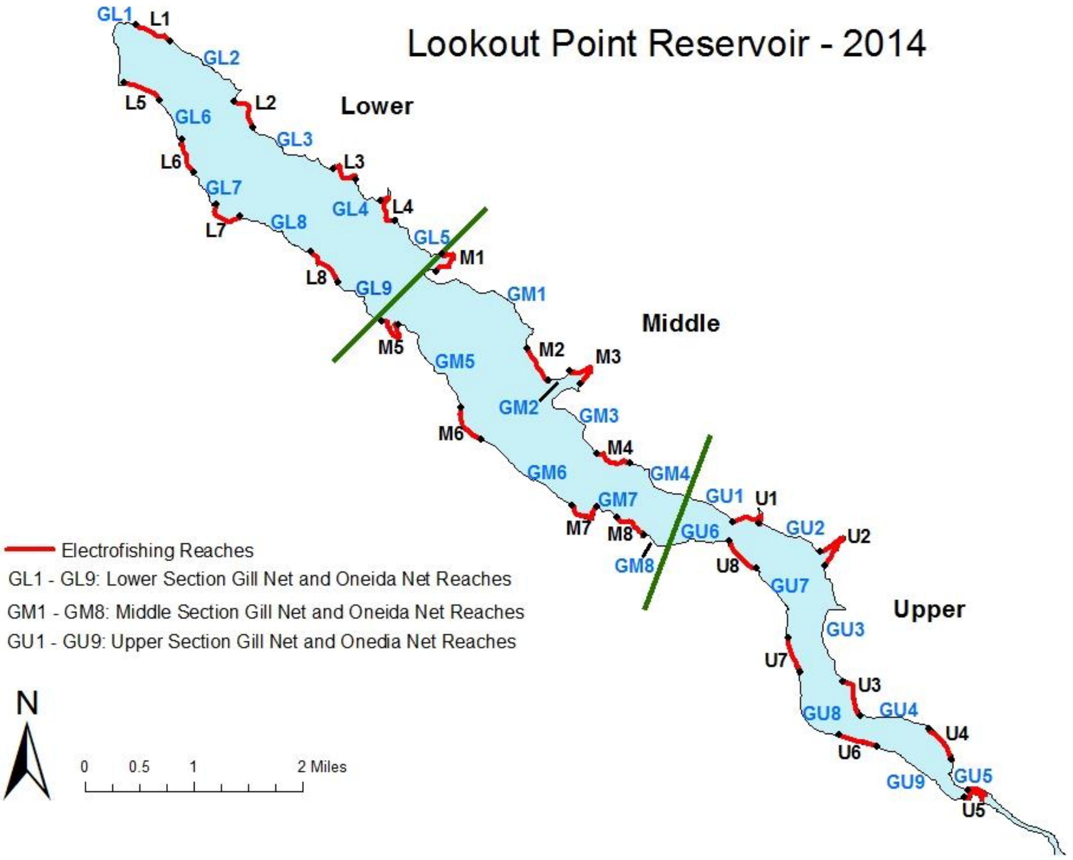

Figure 1-2. Zone and reach breaks used for sampling in Lookout Point Reservoir in 2014 and 2015. Oneida traps and gill nets were located between fixed electrofishing reaches. Reaches upstream of U2 and GU7 were dewatered in 2015 and not sampled.

Statistical Analysis

Data from this standardized study will be used to evaluate effects of a possible drawdown on the abundance, size, and distribution of piscivorous predators species of concern (northern pikeminnow, walleye, largemouth bass, and crappie) in LOP Reservoir. As the drawdown has not yet occurred, data analysis for this report was focused on developing indices that will be used for future pre- and post-drawdown analyses and evaluating possible sources of variability that may ultimately hinder our ability to detect biological changes. Because sampling site selection differed among years (2013 slightly different than 2014-2015), analysis was completed using total data for all years and also for data collected at reaches that were similar among years.

Catch per unit effort (CPUE) was used as a measure of relative abundance for predators collected during electrofishing (fish/900 s) and netting (fish/ 24 h Oneida or gill net sets). The CPUE data were used to evaluate differences in the abundance of predators among years which provided insight on system variability that may confound future analyses after a reservoir drawdown. Comparisons were conducted for each species of concern and by each gear type. Most of the CPUE data were non-normal and/or lacked homogeneity of variances as indicated by

Shapiro-Wilk test results. Therefore, differences in CPUE among years were analyzed with the non-parametric Kruskal-Wallis one-way ANOVA with Dunn's method used for pairwise comparisons.

To determine whether the average size of predators was similar among years, we analyzed fork lengths of species of concern by sampling method. Most of the length data were non-normal and/or lacked homogeneity of variances as indicated by Shapiro-Wilk test results. Therefore, the non-parametric Kruskal-Wallis one-way ANOVA was used to test for differences in fork length among years. For the instances where FL data were normal we used parametric ANOVA for comparison analysis. We also calculated CPUE for each species by 20-mm size groups for each year and gear type to evaluate annual changes in year class strength that could affect overall CPUE for a species.

The CPUE data were also used to analyze predator distribution in LOP Reservoir by comparing average CPUEs among zones within and among years for species of concern. For each species, the gear type that caught the most fish each year was used for distribution analyses. Shapiro-Wilk test results indicated CPUE data were non-normal and/or lacked homogeneity of variances among all zones for both years. As a result, CPUE among zones was analyzed using the Kruskal-Wallis one-way ANOVA on ranks test with Dunn's method used for pairwise comparisons.

We performed statistical analyses only if sufficient numbers of fish were collected (>10 per group). We used an *a priori* critical value of α = 0.05 to determine the significance of all statistical test results. We used SigmaPlot version 12.5 (Systat Software, San Jose, CA) software for all statistical analyses.

Results

Reservoir environmental conditions in May-June were similar in 2013 and 2014 but in 2015 the reservoir was held at a lower elevation and surface temperatures were warmer (Table 1). Dates of sampling varied slightly between years with 2013 Oneida and gill net sets starting earlier than in 2014-2015, and 2013 electrofishing starting later than in 2014-2015 (Table 2).

Table 1-1. Mean (range) elevation and surface temperature of Lookout Point Reservoir during 01 May-30 June of 2013-2015. Elevation is in feet above mean seal level. Temperature data was from the USACE temperature sting located in the reservoir forebay.

Year	Elevation (ft)	Surface temperature (˚C)
2013	905 (900-912)	16.4 (11-22)
2014	908 (899-914)	16.5 (12-20)
2015	859 (855-861)	17.4 (13-23)

The target predator species collected were crappie, northern pikeminnow, largemouth bass, and walleye. The vast majority (95%) of crappie were white crappie but we included both white and black crappie (combined) in the analyses.

We collected 277 predator fish in 2013 and northern pikeminnow were the most numerous species (48%) in our samples (Table 3). Nearly half of the northern pikeminnow were collected by electrofishing. Most largemouth bass and walleye were collected with electrofishing and the majority of crappie were collected with sinking gill nets. Oneida traps were relatively ineffective at collecting predator species with only 18 fish caught in 12 sets in 2013.

In 2014 we more than doubled our electrofishing and gill netting efforts (Table 1) and we collected 652 predator fish (Table 3). Northern pikeminnow catch doubled and largemouth bass and walleye catch increased more than four-fold from 2013, driven mainly by increased catch via electrofishing (Table 3). Northern pikeminnow were again the most numerous species collected (41%) in 2014 but most were collected in gill nets instead of electrofishing (Table 3). Similar to 2013, only 14 target predator fish were caught in Oneida traps in 2014.

In 2015, sampling effort was similar to 2014 and 699 target species were collected (Table 3). We also collected four smallmouth bass (size range: 275-285 mm FL) in 2015, the first year this species was collected in our sampling efforts. Northern pikeminnow catch (n=204) was similar to crappie and bass (Table 3). Only 20 target species were collected in Oneida traps. Because of the low CPUEs associated with the Oneida traps in all three years, we did not include that gear type in our CPUE analyses.

Table 1-2. Period of sampling for predator fish and total effort by gear type and year. Numbers in parentheses are the number of days within each period that sampling occurred.

Gear	Year	Date	Effort
Oneida Lake trap	2013	01 May- 28 June (10 d)	12 sets
	2014	13 May-27 June (12 d)	12 sets
	2015	12 May-25 June (13 d)	14 sets
Gill nets	2013	01 May- 28 June (10 d)	21 sets
	2014	13 May-27 June (15 d)	45 sets
	2015	12 May-26 June (15 d)	45 sets
Electrofishing	2013	28 May- 27 June (6 d)	9.1 h
	2014	05 May-18 June (12 d)	21.0 h
	2015	04 May-17 June (12 d)	20.1 h

Table 1-3. Number of target predator species collected in Lookout Point Reservoir by gear type and year.

Species	Oneida	Gill nets-Floating	Gill nets-Sinking	Electro-fishing	Total
			2013		
Crappie spp.	6	3	78	6	93
Northern pikeminnow	13	30	25	66	134
Largemouth bass	0	0	7	16	23
Walleye	0	0	9	18	27
			2014		
Crappie spp.	7	7	103	25	142
Northern pikeminnow	7	101	106	53	267
Largemouth bass	0	7	17	106	130
Walleye	0	6	18	89	113
			2015		
Crappie spp.	16	6	169	13	204
Northern pikeminnow	4	101	65	34	204
Largemouth bass[a]	0	4	40	159	203
Walleye	0	5	40	43	88

[a] Four smallmouth bass were also collected via electrofishing (1) and sinking gill nets (3).

Predator Species CPUE.- Catch per unit effort by gear type varied significantly among years for some species. Electrofishing CPUE of northern pikeminnow and largemouth bass were significantly different between years, as was northern pikeminnow CPUE in sinking gill nets (Kruskal-Wallis one-way ANOVA, $P<0.05$) (Figure 3). Crappie relative abundance as indicated by sinking gill net CPUE appeared to decrease in 2014 (Figure 3), though CPUE was not significantly different among years.

The difference in CPUE among years for some species does not appear to be result of differences in reach selection protocols between years (random in 2013 versus fixed in 2014 and 2015). In 2013, we randomly selected reaches for sampling. In 2014 we established fixed reaches for electrofishing and netting which included some of the same reaches sampled in 2013. We compared CPUE for those reaches that were sampled at least once in both 2013 and 2014 to assess if between-year changes in CPUE were similar to those observed when comparing the full suite of sampling sites. There were 35 sampling events in reaches that were sampled at least once in both years (10 each with floating and sinking gill nets, and 15 with electrofishing). Similar to what was observed for electrofishing data for the full suite of sites, electrofishing CPUEs for crappie, largemouth bass, and walleye appeared to increase in 2014 compared to 2013, while the electrofishing CPUE for northern pikeminnow significantly decreased in 2014 (Mann-Whitney U-test, $P<0.05$) (Figure 4). Overall, trends in electrofishing CPUE between years were similar whether estimated from the full suite of sites or just the subset of reaches sampled in both years, suggesting interannual differences in CPUE were not caused by different site selection methods.

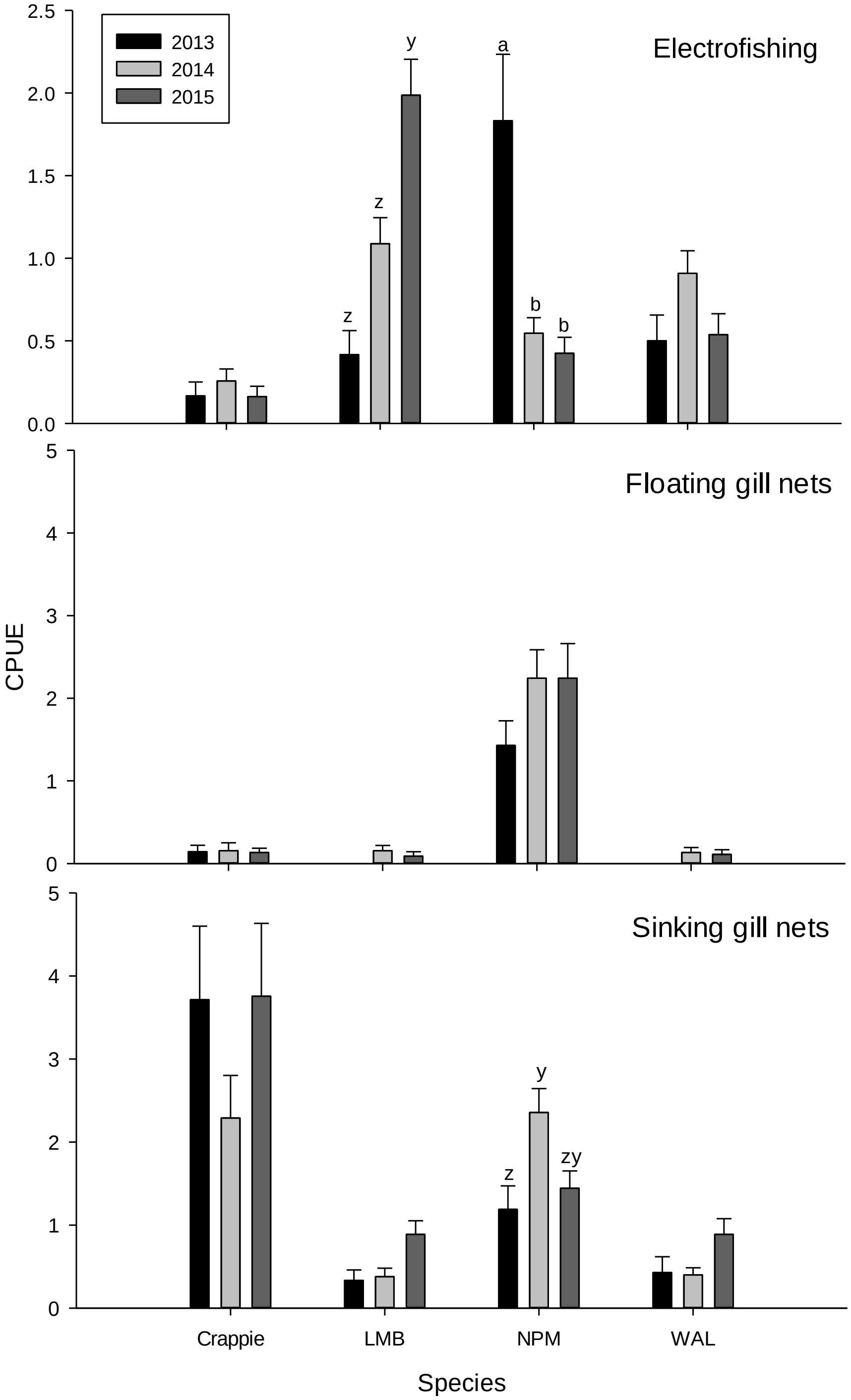

Figure 1-3. Mean catch per unit effort (CPUE) by predator species and year for electrofishing, floating gill nets, and sinking gill nets. Error bars are standard error. NPM=northern pikeminnow; LMB=largemouth bass. Letters not in common within a gear type and species indicate a significant difference among years (*P*<0.05).

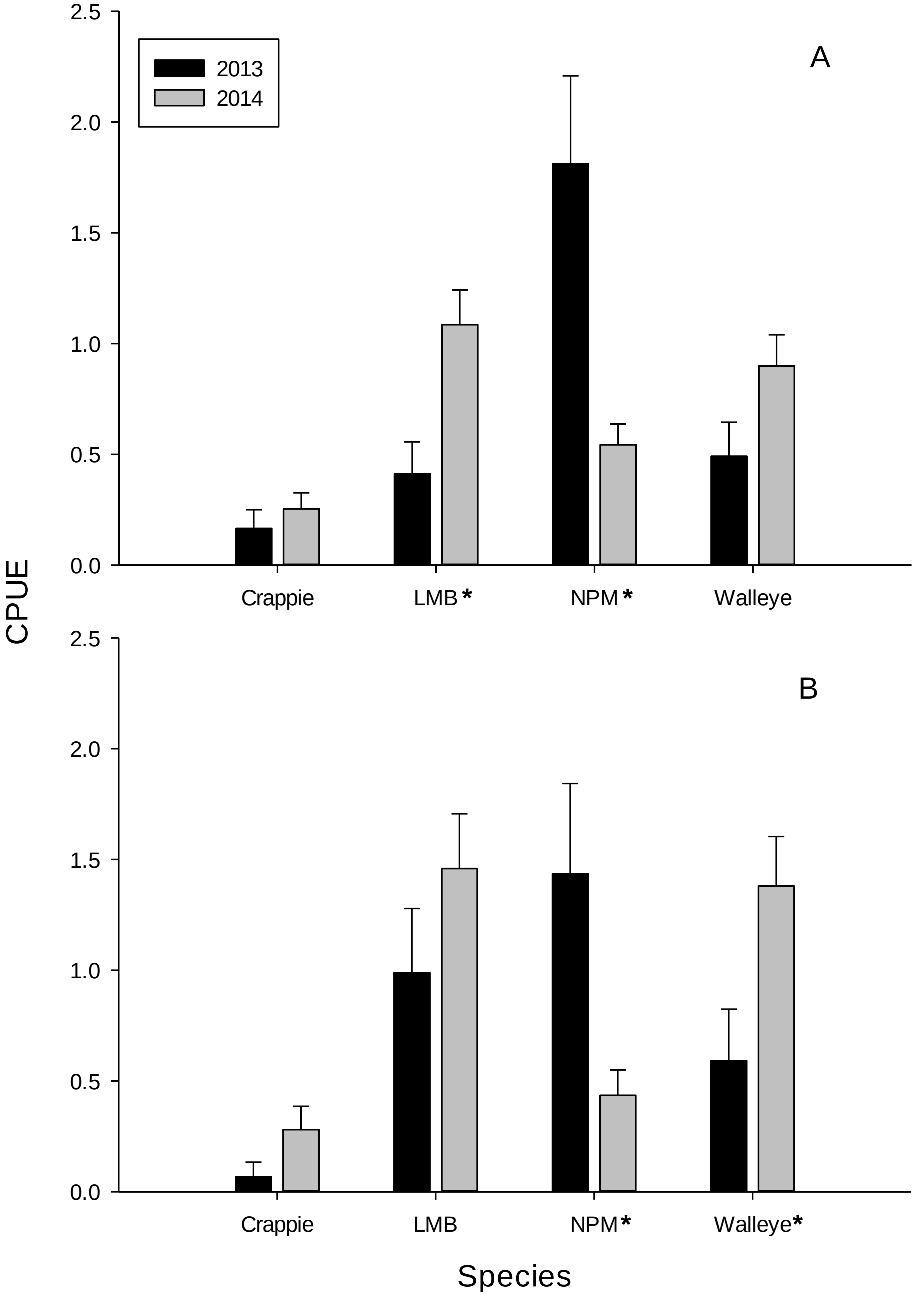

Figure 1-4. Mean electrofishing catch per unit effort (CPUE) by predator species and year for the full suite of sampling sites (A) and just the subset of sites that were sampled in both years (B). Error bars are standard error. NPM=northern pikeminnow; LMB=largemouth bass. Asterisks denote a significant difference between years (*P*<0.05).

CPUE by Fish Size.- For all years, gill nets generally captured larger individuals than electrofishing (Appendix Figure A-1). Differences in species-specific CPUE among years appears to be the result of gear size-selectivity and changes in the size structure of the population as fish within individual cohorts grew and became recruited to or excluded from a gear type. For instance, the significantly greater largemouth bass catch per unit electrofishing effort in 2015 compared to previous years was mainly the result of the increased catch of small fish (<180 mm FL) (Figure 5). This suggests a strong recruitment year in the recent past. Greater catch in 2015 was also partially driven by increased catch of bass 260-340 mm FL compared to previous years. Increased catch of this size group was also reflected in sinking gill net CPUE in 2015 (Figure 5).

The significantly greater northern pikeminnow electrofishing CPUE in 2013 compared to other years was the result of large catches of 200-280 mm FL fish that we did not observe in subsequent years (Figure 6). Although relatively few (n=25) northern pikeminnow were collected in sinking gill nets in 2013, this size group also comprised the greatest portion of the catch. Most northern pikeminnow in 2013 may have been too small to be efficiently captured in gill nets but additional growth by 2014 may have increased their vulnerability to gill netting, possibly explaining the change in CPUE between years and gear type. The size range of northern pikeminnow comprising the greatest sinking gill net CPUE increased from 300-320 mm in 2014 to 340-360 mm in 2015 (Figure 6).

Annual increases in fish size were also evident with crappie caught in sinking gill nets (Figure 7), which may represent fish growth within one or more cohorts. The majority of crappie caught in all years were large (>260 mm FL) with few small fish collected, suggesting weak recruitment in recent years or smaller fish occupy areas that we cannot effectively sample.

Similarly, walleye showed incremental increases in fish size with each consecutive year. The size group with the greatest electrofishing CPUE in 2013 was 200-220 mm FL which increased to 220-240 mm in 2014 and 240-260 mm in 2015.

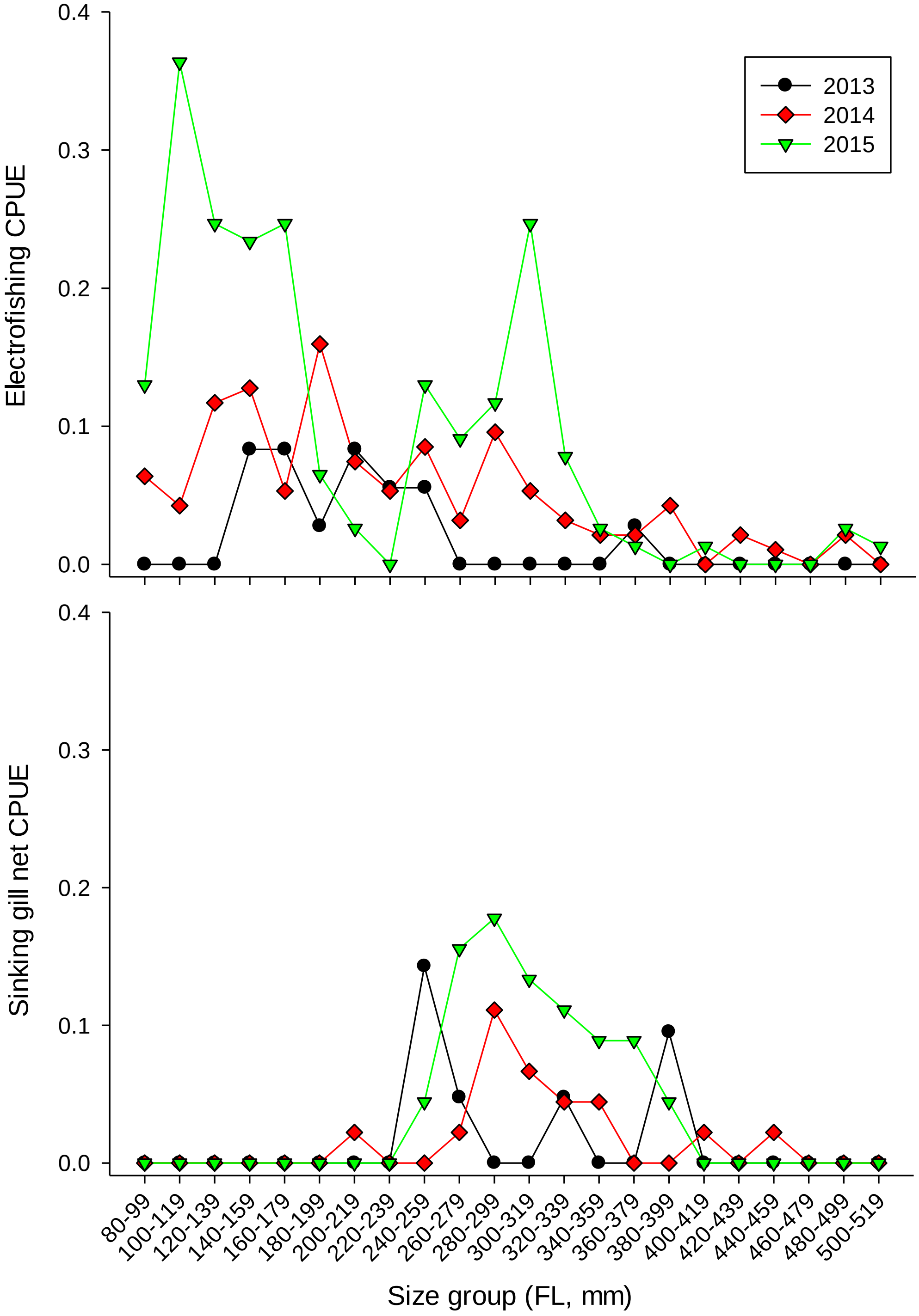

Figure 1-5. Largemouth bass catch per unit effort (CPUE) by size group and year for electrofishing and sinking gill nets in Lookout Point Reservoir, 2013-2015.

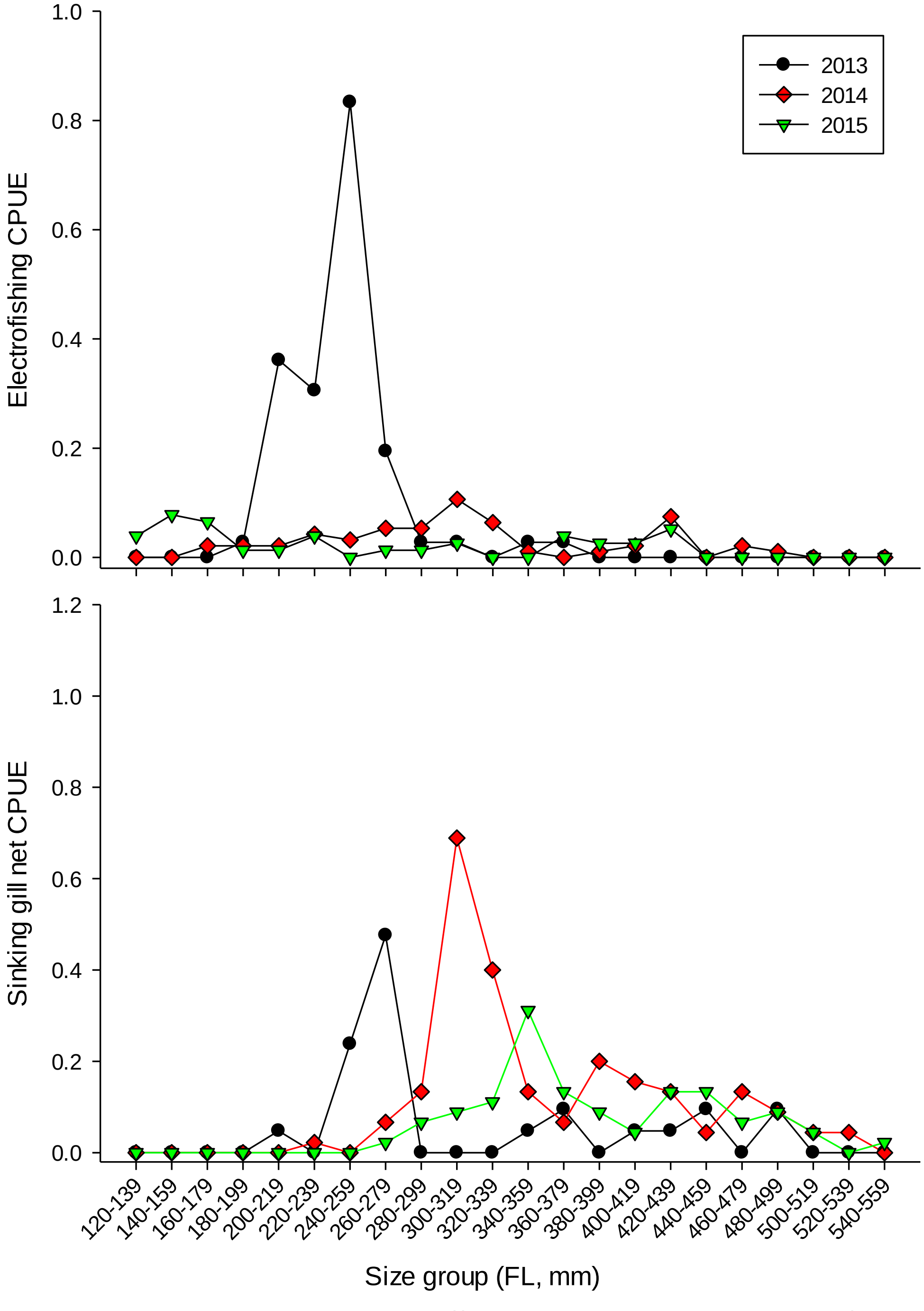

Figure 1-6. Northern pikeminnow catch per unit effort (CPUE) by size group and year for electrofishing and sinking gill nets in Lookout Point Reservoir, 2013-2015.

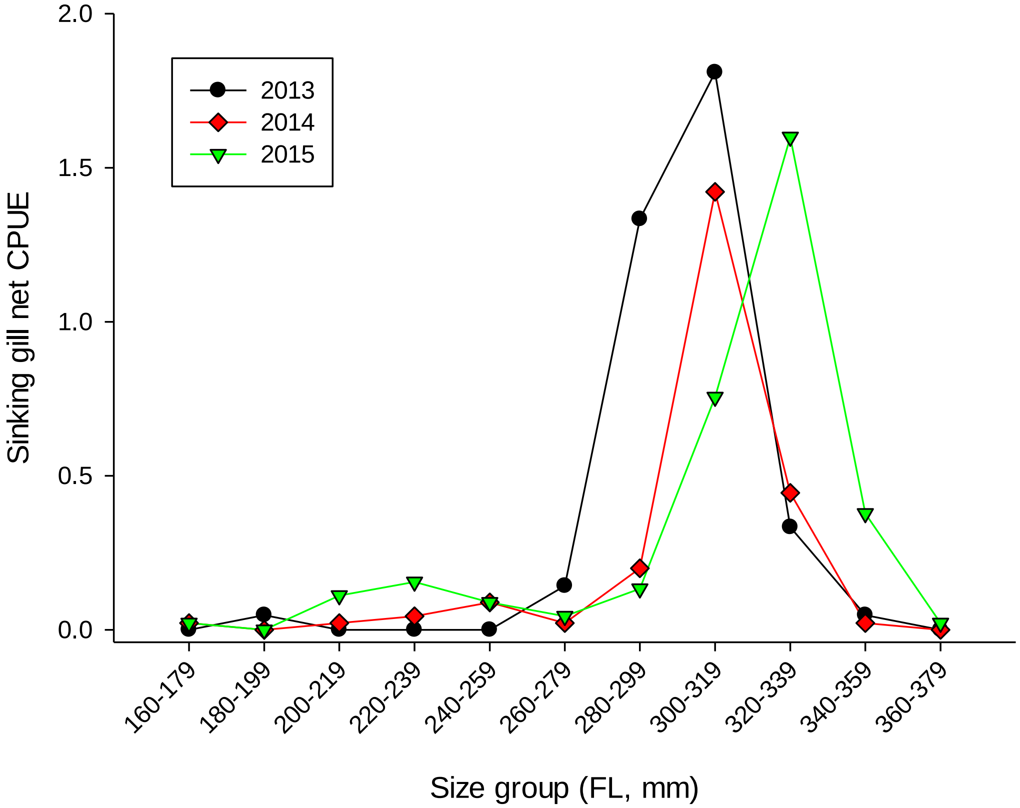

Figure 1-7. Crappie catch per unit effort (CPUE) by size group and year for sinking gill nets in Lookout Point Reservoir, 2013-2015..

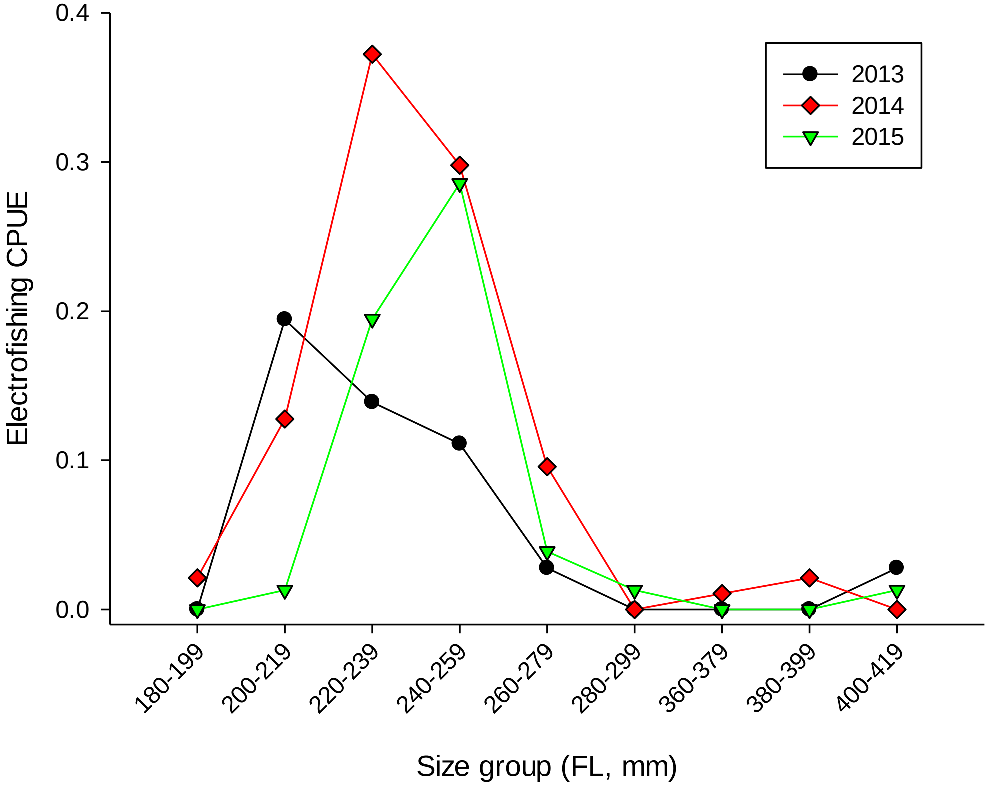

Figure 1-8. Walleye catch per unit effort (CPUE) by size group and year for electrofishing in Lookout Point Reservoir, 2013-2015. .

CPUE by Reservoir Zone.- Predator species tended to be more prevalent in the upper portion of the reservoir. Crappie were less prevalent in the lower zone of the reservoir compared to the middle and upper zones in all years of sampling (Table 4). We could not detect a difference in the size of crappie among zones. Northern pikeminnow captured during standardized electrofishing sampling in 2013 were evenly distributed in the three reservoir zones, but in 2014 and 2015 significantly more were captured from sinking gill net sets in the upper zone compared to the lower zone (Kruskal-Wallis one-way analysis of variance, $P<0.05$) (Table 4). Largemouth bass did not demonstrate a clear pattern in catch among zones. However, the size of bass was significantly larger in the upper zone (Kruskal-Wallis one-way analysis of variance, $P<0.05$) (Figure 9). Similarly, we could not detect a significant difference in catch of walleye among reservoir zones but the largest individuals (>300 mm FL) were only captured in the middle and upper zones (Figure 10).

Table 1-4. Mean catch per unit effort by reservoir zone (Lower, Middle, Upper) for predators collected in Lookout Point Reservoir, spring 2013-2015. Only the data for the most effective gear type for each species and year are shown. Numbers in parentheses are the total number collected by the gear type. Within species and year categories, zones sharing the same letter are not significantly different (*P*>0.05).

Zone	2013	2014	2015
		Crappie	
	Gill net-sinking (78)	Gill net-sinking (103)	Gill net-sinking (169)
Lower	0.57 z	0.40 z	0.47 z
Middle	4.86 y	2.62 zy	7.40 y
Upper	5.71 y	3.71 y	3.40 zy
		Northern Pikeminnow	
	Electrofishing (66)	Gill net-sinking (106)	Gill net-floating (101)
Lower	1.14 z	1.40 z	0.87 z
Middle	2.38 z	2.31 zy	2.87 zy
Upper	1.91 z	3.24 y	3.00 y
		Largemouth Bass	
	Electrofishing (16)	Electrofishing (106)	Electrofishing (159)
Lower	0.99 z	0.74 z	2.38 z
Middle	0.17 z	1.68 z	2.23 z
Upper	0.08 z	0.84 z	0.69 y
		Walleye	
	Electrofishing (18)	Electrofishing (89)	Electrofishing (43)d
Lower	0.90 z	0.92 zy	0.59 z
Middle	0.58 z	1.46 y	0.40 z
Upper	0.00 z	0.34 z	0.69 z

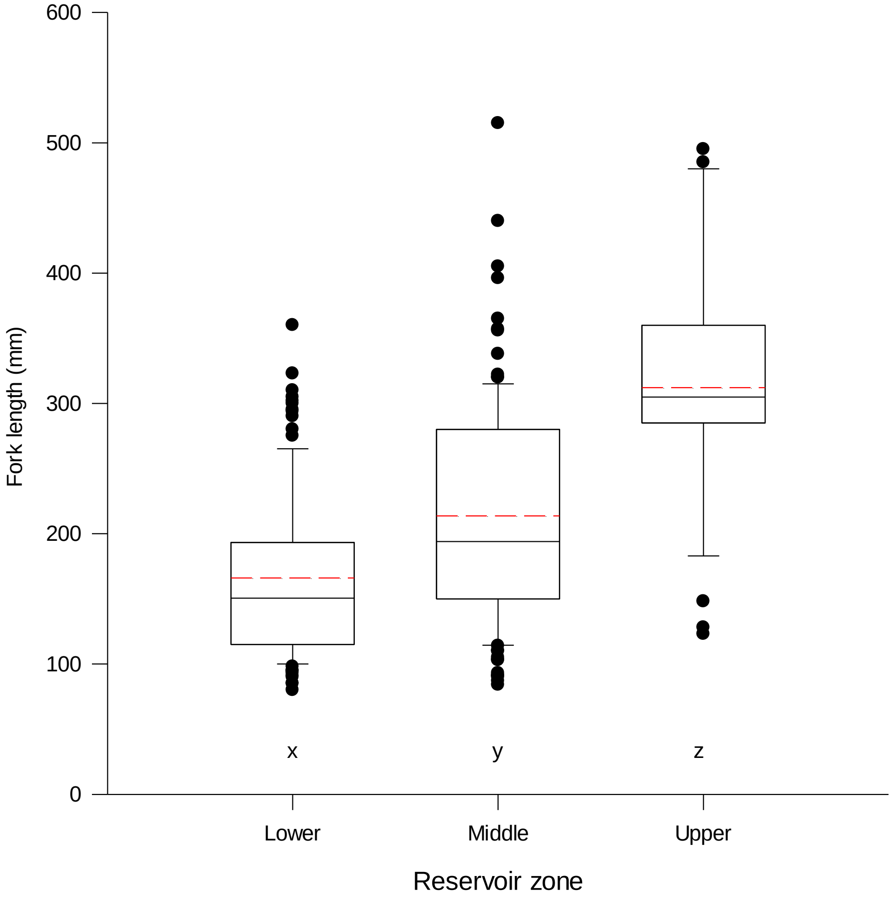

Figure 1-9. Size of largemouth bass by zone of Lookout Point Reservoir, 2013-2015. All fish were caught via boat electrofishing. Solid lines denote medians, red dashed lines denote means, the box represents 25th-75th percentiles, whiskers are the 10th -90th percentile and circles are outliers. Zones sharing the same letter are not significantly different (*P*>0.05) .

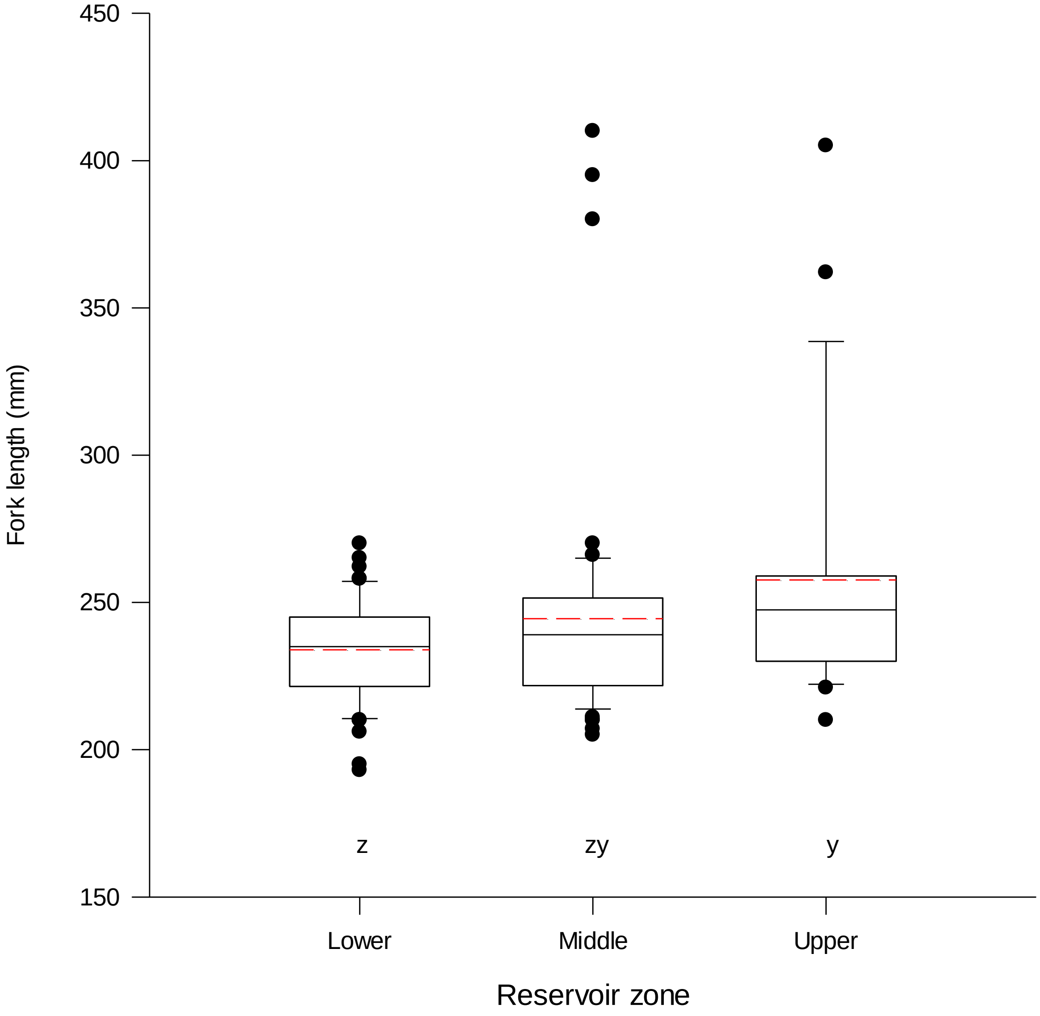

Figure 1-10. Size of walleye by zone of Lookout Point Reservoir, 2013-2015. All fish were caught via electrofishing. Solid lines denote medians, red dashed lines denote means, the box represents 25th-75th percentiles, whiskers are the 10th -90th percentile and circles are outliers. Zones sharing the same letter are not significantly different (*P*>0.05) .

Discussion

Electrofishing generally caught a wider size range of predator fish whereas gill nets tended to catch larger individuals, a trend also reported by Beamesderfer and Rieman (1988) using similar gear in the John Day Reservoir to capture northern pikeminnow, walleye, and smallmouth bass (*M. dolomieu*). The variability in individual species CPUE among years in our study was likely due to size selectivity of the gear types and changing size structure of predator species. The majority of the northern pikeminnow in 2013 were 220-260 mm FL and collected during electrofishing, whereas in 2014 and 2015 most of the northern pikeminnow were >280 FL and captured in gill nets. These fish could be from the same year class and grew large enough to become more vulnerable to gill netting in later years. The significant increase in largemouth bass catch via electrofishing in 2015 appears to be the result of recruitment of younger fish into this gear type, suggesting a relatively recent strong cohort.

Northern pikeminnow were the most numerous species collected in the reservoir in 2013 and 2014 but where similar in number to bass and walleye in 2015. Northern pikeminnow are a slow growing, long-lived species that can live up to 19 years (Wydoski and Whitney 2003) and reach sexual maturity at 3-8 years, between 200-350 mm in length. Northern pikeminnow catch was significantly greater in the upper reservoir in 2014-2015. Although we could not detect the same distribution pattern in 2013 with just our standardized electrofishing effort, our total sampling effort in 2013 (including sampling for the population estimate) indicated northern pikeminnow abundance was greater in the upper reservoir in 2013 as well (Monzyk et al. 2013).

In 2013, we estimated 7,067 (95% CI 5,466 – 9,224) northern pikeminnow ≥150 mm FL resided in LOP reservoir based on closed-capture model of PIT-tagged fish (Monzyk et al. 2013). We believe this was an underestimate due to the large zones (low spatial resolution) used in the model for estimating abundance, along with very low capture probabilities. This was substantiated with recaptures of PIT-tagged fish in 2014. We tagged 844 northern pikeminnow in 2013; an estimated 11.9% (9.2 – 15.4%) of the population. A 150-mm FL fish would be expected to grow ~80 mm in a year to approximately 230 mm FL (Wydoski and Whitney 2003). In 2014, we captured 276 northern pikeminnow ≥230 mm FL (accounting for growth), of which 27 were PIT-tagged (8.0%). The percent of tagged fish recaptured in 2014 suggest the true population abundance in 2013 was about 10,000 northern pikeminnow.

Adult walleye were first reported in LOP in 1998 and the first documented reproduction of walleye in the reservoir was in 2007 (Kelly Reis, ODFW, pers. comm). There is some evidence to suggest walleye experience variability in successful spawning and recruitment in the reservoir. The size group with the greatest catch per unit effort incrementally increased with each consecutive year, likely representing growth of fish from a single cohort. Based on published length at age data for walleye (Wydoski and Whitney 2003), 2012 was the most likely year of this dominant cohort. In previous years of sampling fish in LOP (2010-2013), walleye catch was dominated by large individuals (>500 mm FL) which were likely age 5 or older. The catch of smaller walleye in recent years suggests strong recruitment of a younger year class (BY 2012) while the number of larger, older fish are declining. Walleye in the Columbia River are known to have highly variable year-class strengths with occasional dominant years (Rieman and Beamesderfer 1990; Friesen and Ward 2000).

A boom and bust population dynamic was also evident with white crappie. Crappie in reservoirs are known to have a cyclic nature to their abundance, with periodic strong year-classes occurring at intervals every 3-5 years (Swingle and Swingle 1967). In LOP, crappie catch in all years was dominated by large individuals, presumably from the same year class. Most crappie we captured in 2014 were 300-340 mm FL which roughly corresponds to age-4 fish (BY 2010) according to Wydoski and Whitney (2003) for crappie in western Oregon. In 2010 we captured several thousand young-of-year crappie in LOP and have not observed similar large catches of young-of-year crappie in subsequent years. If no new large recruitment occurs in LOP, we could expect crappie numbers to decrease in the next few years since most white crappie do not live more than six years (Wydoski and Whitney 2003).

Largemouth bass length-frequency did not show a dominant year-class like walleye or crappie. In 2014 and 2015, with additional sampling effort, we captured a broader size range of fish than in 2013. The broad size range of largemouth bass suggests a more consistent recruitment each year. Although the large catch of largemouth bass 100-180 mm FL in 2015 was not observed in previous years. This size range likely corresponds to age-2 fish (2013 cohort) based on published length at age data (Wydoski and Whitney 2003), and suggests a strong recruitment that year. The largest bass tended to be captured in the relatively shallow upper zone of the reservoir and may be an indication of spawning adults using this area in the spring.

The presence of smallmouth bass for the first time in our catch in 2015 suggests a recent reintroduction of this species, likely from Dexter Reservoir. In Foster Reservoir, smallmouth bass were introduced onto an established largemouth bass population in the 1980s. Based on ODFW fish surveys conducted in the reservoir, it appears smallmouth had largely supplanted largemouth in a little over a decade (Monzyk et al. 2014). Whether the same trend will occur in Lookout Point Reservoir is unknown.

One issue that could complicate an analysis of drawdown effects on predator populations is the variability in year-class strength that may mask the effect of the reservoir operation. To avoid this, a pre-drawdown assessment of year-class strengths should be conducted immediately prior to the drawdown.

SECTION 2: RADIO-TELEMETRY STUDY OF NORTHERN PIKEMINNOW IN LOOKOUT POINT RESERVOIR AND THE MIDDLE FORK WILLAMETTE RIVER

Background

Northern pikeminnow are one of the most common predator species in LOP. Monzyk et al. (2013) estimated the number of large (≥150 mm FL) northern pikeminnow in the littoral zone of Lookout Point Reservoir to be about 7,100 individuals which consume an estimated 102,000 juvenile Chinook salmon every year from April-June (0.160 fish/day). Northern pikeminnow are a slow growing, long-lived species that can live up to 19 years (Wydoski and Whitney 2003) and reach sexual maturity at 3-8 years, between 200-350 mm in length. Northern pikeminnow can spawn in either the reservoirs if suitable habitat exists or in streams upstream of reservoirs (Jeppson and Platts 1988). Management actions to limit predation on juvenile Chinook could include manipulating reservoir operations to disrupt northern pikeminnow spawning. A detailed understanding of habitat use, movement, and spawning behavior would be required for a successful management strategy. To provide a better understanding of northern pikeminnow use and spawning in LOP Reservoir, we initiated a radio-telemetry study to track movement and understand their spawning requirements.

Methods

Northern pikeminnow collection.- Northern pikeminnow were collected May 4 – 19, 2015 in Lookout Point Reservoir during night boat electrofishing sessions. Each session lasted 900 seconds (Smith Root model 2.5 generator powered pulsator; 1,000 V; pulse width 5 ms; frequency 120 DC) and larger pikeminnow collected were held in a live-well (0.61 x 0.61 x 0.91 m) on the boat where water was aerated and recirculated. Smaller fish or non-target species were not netted or returned to the reservoir immediately. At the end of each session the fork length of each pikeminnow was measured (mm) and those >350 mm were placed in 0.61 x 0.91 m floating net pens (maximum 3 fish per pen) over-night at the location where the session ended. The following morning the tagging crew arrived at the reservoir and tagging commenced only if the target fish appeared healthy and surface water temperatures were <20°C.

Radio-tagging.- Prior to tagging each fish, all gear used for implanting /surgery was disinfected and sanitized with 95% ETOH for at least ten minutes and rinsed with distilled water. An anesthetic bath of tricaine methane sulfonate (80 mg/L MS-222 buffered with 200 mg/L $NaHCO_3$) and 18.93 liters of maintenance anesthetic at half concentration (50 %) were prepared and a recovery cooler (454 L) was filled with reservoir water.

Two coded radio tag models from Lotek were used for this study: model SR-M16-25 (2000 code set, frequencies 151.480 and 151.560) with an estimated tag life of six months and an average weight of 17.5 g in air were used for fish ≥400 mm FL (≥ 580 g); and model NTC-6-1 (2000 code set, frequency 151.360) with an average weight 2.8 g were used for fish <400 mm FL (<580 g). The goal was to limit tag burden to ≤3% of body weight for all fish. All tags were programmed for 5-s burst rate. The larger tags were equipped with motion sensors and programmed to emit a different code if motion stopped for 24 h indicating mortality. Each tag was activated and frequency and the radio code number were recorded prior to implantation. Northern pikeminnow were anesthetized individually, fork length was measured, weight recorded, and PIT-tagged prior to surgery. Once fish reached stage 4 anesthesia (Summerfelt and Smith 1990; 2-5 minutes) and had lost equilibrium it was placed ventral side up on a tagging cradle and kept moist. The gravity feed tube (1.27-cm diameter) from the maintenance anesthetic bath was placed in the mouth and a half-concentration solution was perfused over the gills (Figure 2-1). An incision was made with a scalpel (6-8 mm) anterior to the pelvic girdle and to the side of the mid-ventral line and a cannula with the sheath still in place was inserted through the incision. The cannula was run along the inside body wall of the fish and pushed through the sheath and through the body wall exiting at a point between the pelvic fins and the anal fin. The sheath was then removed (backed out) and the radio antenna was run through the cannula and the cannula was pulled through the body wall. The slack in the antenna was removed by pulling it through the body wall and the radio tag was inserted into the coelomic cavity through the incision. To close the incision we used three 4-0 Ethicon Monocryl monofilament sutures and 3-1-1 uninterrupted knots with throws in alternating directions, and the northern pikeminnow was placed in the recovery cooler with aeration for recovery. After recovering equilibrium and responding to external stimuli the fish was released.

Figure 2-1. Northern pikeminnow surgically implanted with a radio transmitter.

Radio tracking.- Mobile tracking was conducted from May 13 through September 11, 2015 at least every two weeks. Reservoir elevations during the tracking period ranged from 849-861 ft above mean sea level, approximately 65 ft lower than normal pool levels. Tracking was primarily by boat in the reservoir and by truck or foot along the rivers upstream of the reservoir. We used Lotek model SRX400 receivers and Yagi aerial antennas to pinpoint the location of tagged fish. When using the boat we traveled along the entire perimeter of the reservoir at approximately 20 m from shore with the receiver set to a high gain and in scan mode. Once a tag was detected, the code was identified and we pinpointed its location by gradually lowering the gain and following the direction of the strongest signal with the directional Yagi antenna. We assumed we were very close to the fish's location and recorded GPS coordinates when we were able to still detect the tag with high power while the receiver was set to a low gain. While using the truck and on foot we tracked the tag to the lowest gain and highest power of the signal we could detect and estimated the position based on the direction of the signal. Coordinates were plotted on a map using ArcMap 10.2.2.

Results

We tagged 12 adult northern pikeminnow ranging in size from 374-463 mm FL (Table 2-1). Most fish were captured and tagged in the upper zone of the reservoir. Tracking was conducted weekly from May 13 – August 3 with a follow up survey conducted on September 11. Most fish were detected during each of the 18 separate tracking occasion. One fish (151.370, code 16) was tagged and released on 05 May 2015 and subsequently recovered dead in a gill net on 11 June 2015, approximately 2.8 km from its release location on the opposite side of the reservoir. Another fish (151.370, code 25) tagged on 19 May was first detected on 11 June at a location downstream and across the reservoir approximately 1.4 km from its release location. This fish did not move from this initial detection location in subsequent tracking occasions and was presumed dead.

Table 2-1. Fish and radio transmitter information for northern pikeminnow tagged in Lookout Point Reservoir, 2015. Numbers in parentheses are the number of separate occasions the fish was detected within tracking period.

Fish ID	Tag date	Release zone	Fork length (mm)	Weight (g)	Tag type	Frequency	Code	Tracking period
1	May 05	Lower	410	740	SR-M16-25	151.560	42	May 13-Jul 31 (8)
2	May 05	Lower	391	510	NTC-6-1	150.370	16	May 13 – Jun 11 (2)
3	May 05	Lower	440	1080	SR-M16-25	151.480	30	May 13-Sep 11 (11)
4	May 06	Upper	425	980	SR-M16-25	151.560	44	May 13-Sep 11 (15)
5	May 06	Upper	420	880	SR-M16-25	151.560	45	May 13-Sep 11 (12)
6	May 06	Upper	380	480	NTC-6-1	150.370	29	May 13-Sep 11 (11)
7	May 06	Upper	463	880	SR-M16-25	151.480	29	May 13-Sep 11 (11)
8	May 06	Upper	404	580	SR-M16-25	151.560	39	May 13-Sep 11 (13)
9	May 19	Upper	374	470	NTC-6-1	150.370	39	Jun 4-Jul 16 (5)
10	May 19	Upper	386	520	NTC-6-1	150.370	25	Jun 11-Sep 11 (5)
11	May 19	Upper	425	980	SR-M16-25	151.480	28	May 21- Sep 11 (12)
12	May 19	Middle	390	560	NTC-6-1	150.370	30	May 21- Sep 11 (10)

The remaining 10 fish demonstrated two distinct movement patterns: fish that stayed in the reservoir during the entire study period (n=6); and those that moved upstream into the Middle Fork Willamette River at some point during the study (n=4). Fish that remained in the reservoir generally exhibited localized movements. The average distance traveled between detections was 1.1 km (range: 0.3-6.3 km) and travel distance was not related to the number of days between detections (Simple linear regression; $P>0.05$) (Figure 2-2). Fish were equally likely to move either upstream, downstream, or across the reservoir (Figure 2-3).

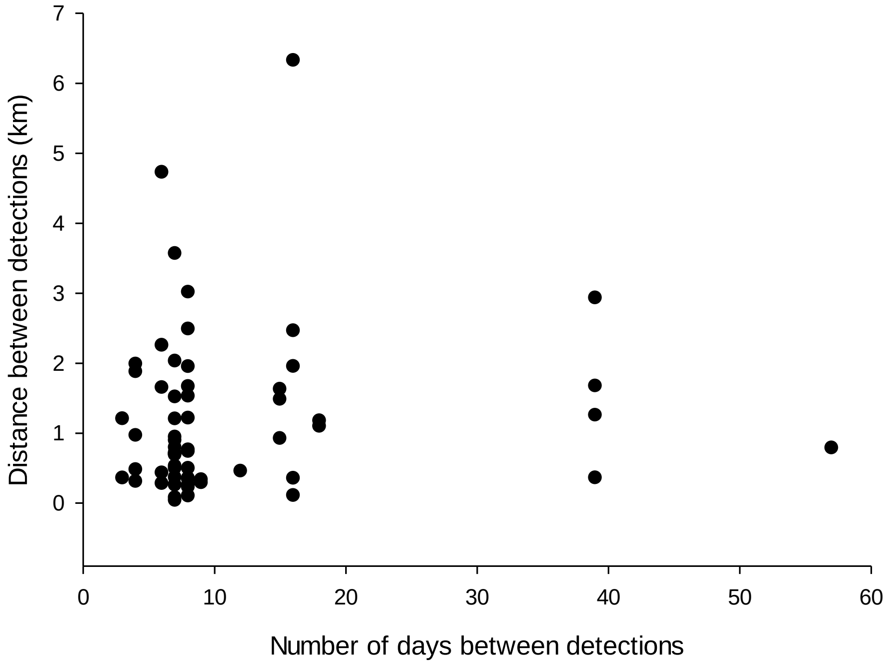

Figure 2-2. Relationship between distance traveled and number of days between consecutive detections for radio-tagged northern pikeminnow that remained in the reservoir for the entire study period, 2015.

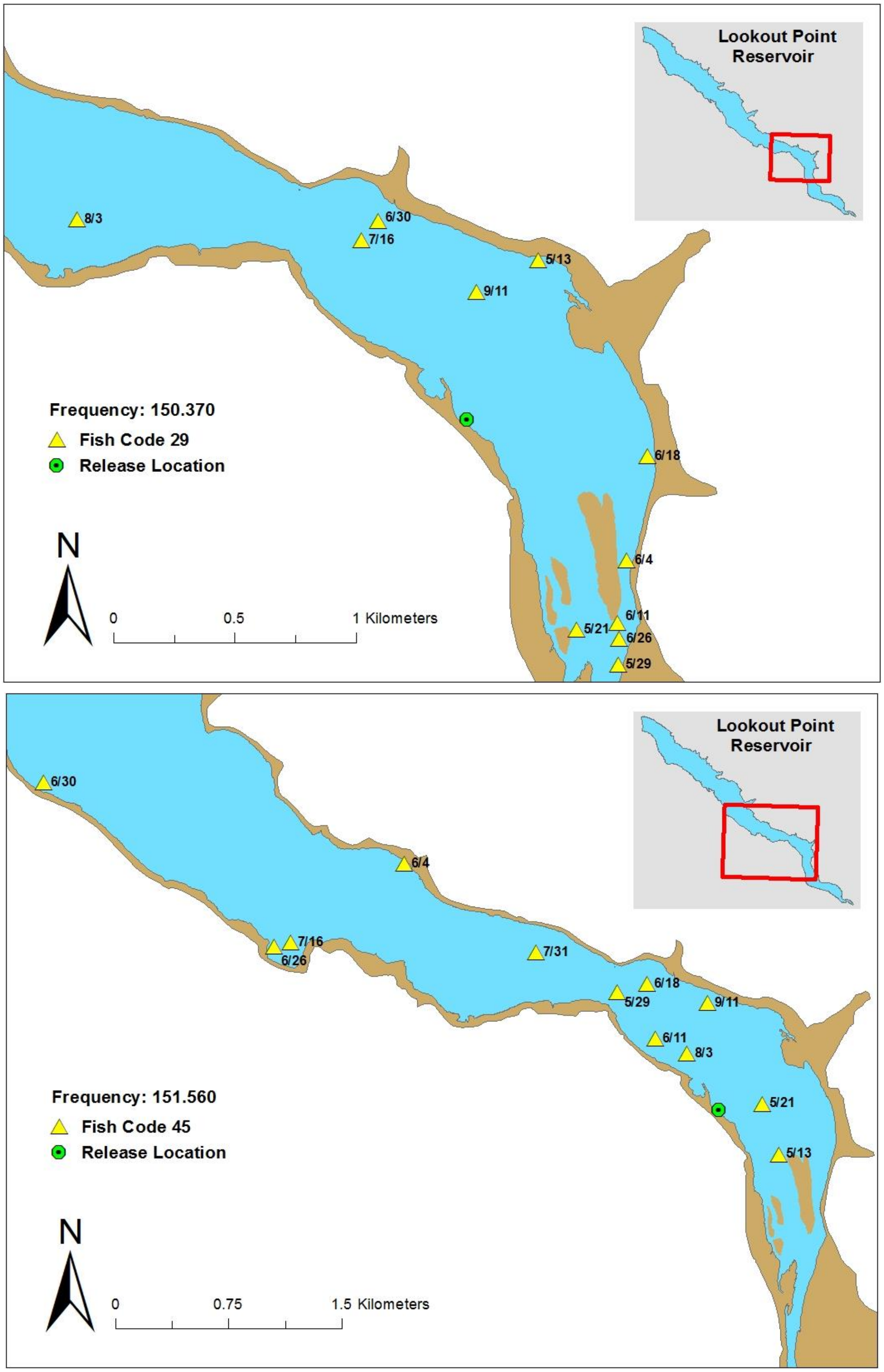

Figure 2-3. Locations and detection dates of two radio-tagged northern pikeminnow that remained in Lookout Point Reservoir throughout the study period, 2015. Maps show the reservoir at normal full conservation pool (brown) and at 860-ft elevation during the study (blue).

Four fish were tracked on 08 June to a single pool on the Middle Fork Willamette River (MFW) just upstream of the Black Canyon campground (rkm 355), approximately 7.5 km upstream from the head of the reservoir. Three of these fish were subsequently located in the lower North Fork Middle Fork River (NFMF) by mid-June, or 14 km upstream from the head of the reservoir. Two of the three fish were initially tagged in the lower reservoir, remained in the NFMW until late June, and returned to the lower reservoir by July (Figure 2-4). The third fish that entered the NFMF in June was initially tagged in the upper reservoir, descended in late June to a pool on the MFW at the confluence with the NMFW, then in late July traveled up the MFW approximately 2.6 km to a large pool near the Highway 58 bridge where it remained for the rest of the study period.

Two of the three fish in the NFMF were located from mid-June through late June in a large trench pool near the town of Westfir along with ~100 other large northern pikeminnow in what we inferred was a spawning aggregation (Figure 2-5). The forth fish that had entered the MFW and located at rkm 355 on 08 June was subsequently detected slightly upstream (rkm 357) in early July, and then descended back to the upper zone of the reservoir by mid-July.

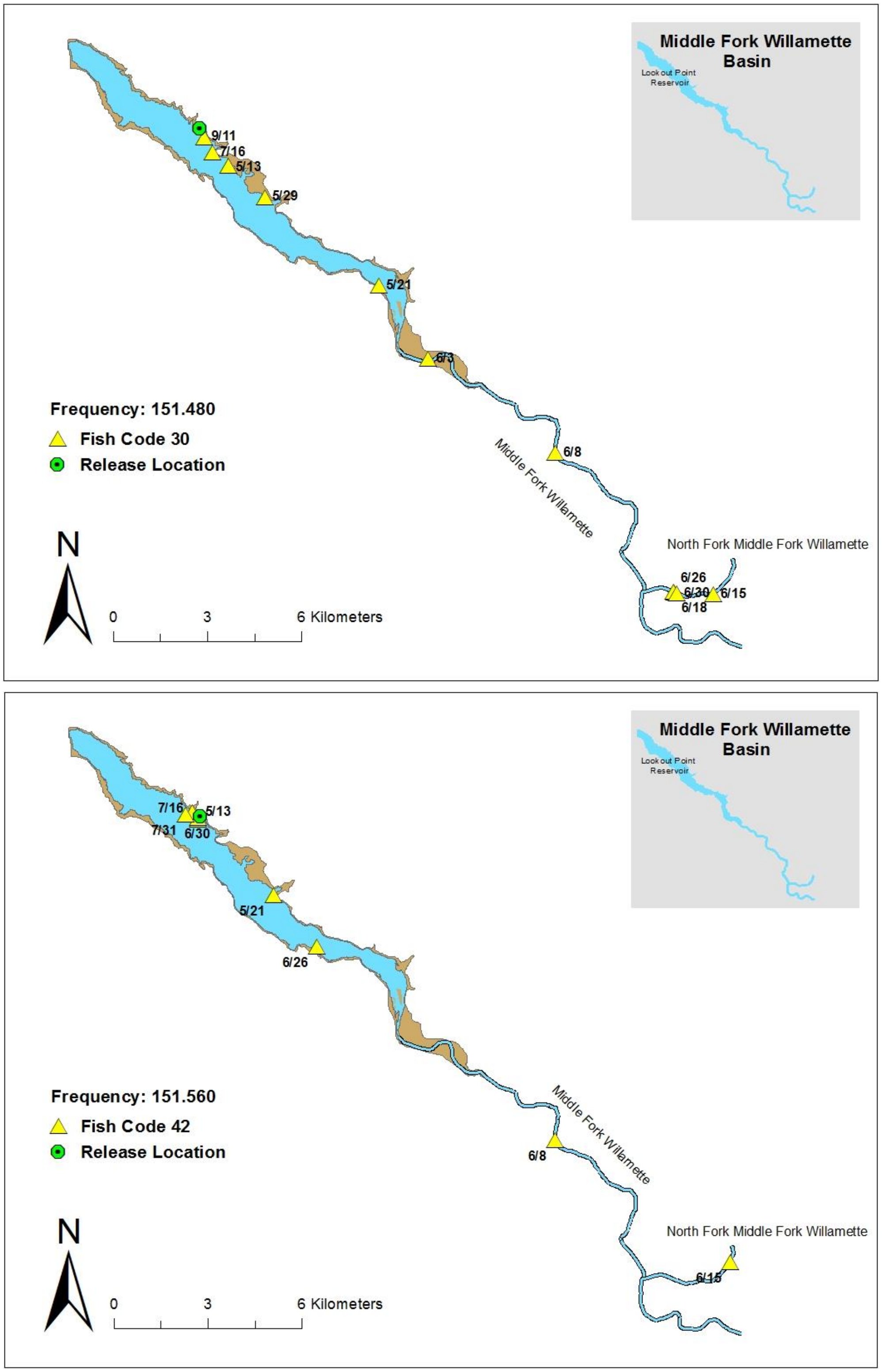

Figure 2-4. Locations and detection dates of two radio-tagged northern pikeminnow that travelled upriver from Lookout Point Reservoir in 2015. Maps show the reservoir at normal full conservation pool (brown) and at 860-ft elevation during the study (blue).

Figure 2-5. Northern pikeminnow congregated in a large trench pool of the North Fork Middle Fork Willamette River in June, 2015. Two radio-tagged fish were in the pool with approximately 100 similar-sized northern pikeminnow in what was inferred to be a spawning aggregation. Numerous (n≈200) largescale suckers were also in the pool.

Discussion

Northern pikeminnow in LOP were more abundant in the upper reservoir zone in the spring (see Section 1) and remain in this zone through summer. The spatial area northern pikeminnow occupied in the reservoir suggest that overlap exist with juvenile Chinook salmon prey in the spring but may be minimal by early summer. Although juvenile Chinook salmon are present in the upper reservoir in early spring but in the summer rarely used this shallow and warm part of the reservoir (Monzyk et al. 2015). A previous study on northern pikeminnow diet showed that northern pikeminnow consumption of juvenile Chinook salmon occurred in the spring and juvenile crappie composed the majority of prey items in the summer (Monzyk et al. 2013).

Northern pikeminnow can spawn in either lakes or streams (Jeppson and Platts 1959) with males potentially outnumbering females on spawning grounds 100:1 (Wydoski and Whitney 2003). It is possible that spawning occurs in multiple locations in and upstream of LOP. The approximately 100 large pikeminnow observed in a single pool in the lower NFMF Willamette River in June is indicative of a spawning aggregation. The fact that all four fish that entered the river were initially together in a single pool of the MFW in early June may indicate spawning occurred at this location. Several fish were located in the upper reservoir along a shallow rocky shoreline across from School Creek in late May- early June. One fish tagged in the middle reservoir zone moved to this location in late May then returned to middle of the reservoir by early June. Although spawning could not be confirmed, the habitat in this area was shallow and rocky, typical of spawning habitat in lakes (Jeppson and Platts 1959). If spawning does occur in the reservoir, the location may vary each year depending on reservoir elevations in the spring. Although northern pikeminnow appear to spawn in the river, other predator species in LOP (e.g., crappie and largemouth bass) are likely to be obligate reservoir spawners.

Recommendations

Predator species have a negative impact on threatened Chinook salmon juveniles rearing in LOP Reservoir, and possibly other reservoirs in the Willamette Basin. Managing predator populations to increase Chinook salmon survival would aid in recovery and improve the chances for a successful Chinook salmon reintroduction program. One option for managing predator populations is manipulating reservoir elevations during the peak spawning to reduce juvenile recruitment by either disrupting spawning or limiting the extent and quality of vegetated rearing areas for newly hatched fry. This could be especially effective for obligate reservoir spawners like crappie and largemouth bass that build nest in shallow shoreline areas in late spring. Fluctuating reservoir elevations during crappie spawning has been shown to limit successful year-class recruitment (Beam 1983). Water turbidity post-spawn has been shown to negatively affect subyearling crappie recruitment (Mitzner 1991). Similar to crappie, fluctuating water levels by just a few meters during largemouth bass spawning has been shown to disrupt hatching success in Illinois reservoirs (Kohler et al. 1993). These authors suspected that nest desertion by male guards, egg desiccation, or egg retention by females were responsible for the reduced hatching success.

Crappie and largemouth bass spawn when surface water temperatures reach 16-20°C (Siefert 1968, Miller and Friesen 2012), which corresponds to mid-May through June during most years in Lookout Point Reservoir. Juvenile Chinook salmon have largely moved into the pelagic zone of the reservoir by this time of year (Monzyk et al. 2011, 2013), so presumably they would be little affected by reservoir level fluctuations.

The first step in managing predator populations would be understanding the spawning requirements and timing of each predator species in Lookout Point Reservoir. Radio-telemetry studies are one option that could provide detailed information on predator species spawn timing and habitat requirements. In addition, indexing the fry abundance of predator species in shallow rearing areas would provide baseline information on fry density and rearing habitat and could be used to investigate the effects of reservoir level manipulations on predator fry recruitment.

Northern pikeminnow are not obligate reservoir spawners, so they are not as vulnerable to reservoir level manipulation as other predator species. However, northern pikeminnow appear to congregate in the spring at the head of the reservoir, prior to or during spawning. Targeted removal of predator fish may be one management option to control recruitment of this species, especially if the spawning population is concentrated during certain times of the year. Targeted removal of northern pikeminnow in the Columbia and Snake rivers has proven successful in reducing predation on juvenile Chinook salmon (Friesen and Ward 1999).

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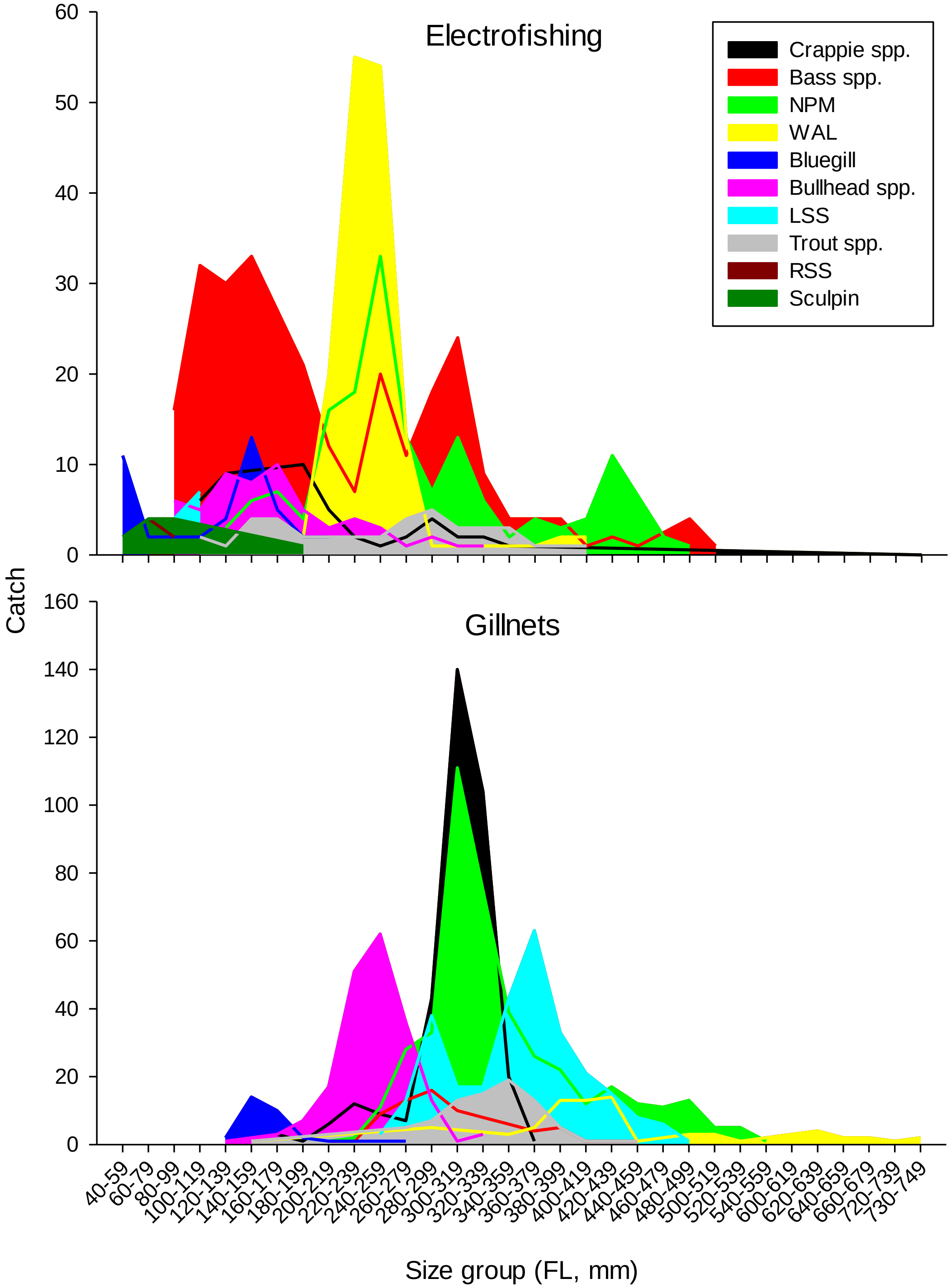
Appendix



Appendix Figure A-1. Length frequency of fish captured in Lookout Point Reservoir by species and gear type, 2013-2015. Gillnets include both sinking and floating nets.

Appendix Table A-1. Length at age of northern pikeminnow collected in Lookout Point Reservoir in 2014. Age determined from reading scales.

Age	N	Mean fork length (mm)	Min	Max
3	6	301	275	325
4	68	314	265	402
5	13	336	275	396
6	9	382	316	432
7	9	405	321	480
8	2	387	295	479

Appendix Table A-2. Fork length (FL; mm) of predator species collected in Lookout Point Reservoir in May-June by gear type and year. CRA=crappie; NPM=northern pikeminnow; LMB=largemouth bass, and WAL=walleye.

Gear type/ FL	CRA	NPM	LMB	WAL	CRA	NPM	LMB	WAL	CRA	NPM	LMB	WAL
	2013				2014				2015			
Electrofishing												
Mean	257.7	242.4	204.4	236.1	166.1	311.7	222.8	240.7	230.0	259.9	197.3	247.3
Median	285.0	243.5	201.0	220.0	135.0	304.0	198.5	236.0	215	230	165	245
N	6	66	15	18	25	53	106	89	13	34	159	43
SE	21.74	3.70	14.43	11.08	12.73	11.13	8.99	3.31	16.19	19.34	7.26	4.28
Oneida												
Mean	273.3	248.2	–	–	222.0	306.0	–	–	126.8	284.0	–	–
Median	292.5	250.0	–	–	310.0	315.0	–	–	55	185	–	–
N	6	13	–	–	7	7	–	–	16	3	–	–
SE	20.07	5.66	–	–	49.27	41.86	–	–	26.95	108.12	–	–
Floating Gill Net												
Mean	256.0	312.7	–	–	321.3	326.2	275.7	506.8	270.3	333.4	249.5	451.2
Median	275.0	300.5	–	–	320.0	315.0	276.0	526.5	244	325	244	430
N	3	30	–	–	6	92	7	6	6	101	4	5
SE	42.36	10.65	–	–	5.20	3.73	10.38	66.50	21.19	5.38	13.15	17.69
Sinking Gill Net												
Mean	300.4	317.1	302.1	522.2	305.2	358.0	321.6	436.6	311.4	387.3	312.1	426.3
Median	300.0	265.0	260.0	520.0	311.0	328.0	308.0	383.5	323	373	305.5	416.5
N	78	25	7	9	104	115	16	18	149	61	38	40
SE	2.74	17.23	22.95	49.57	2.47	6.32	14.72	26.82	2.91	8.34	6.21	15.68